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SELF EXTINGUISHING GAS GENERATING PROPELLANT AND SYSTEM  
THEREOF

Charles R. McCulloch

Department of the Navy  
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SELF EXTINGUISHING GAS GENERATING  
PROPELLANT AND SYSTEM THEREOF

ABSTRACT OF THE DISCLOSURE

A gas generating propellant, which is self-extinguishing at high pressures when used in a system, comprises a perchlorate or a nitrate, as an oxidizer, a binder, a coolant, and a catalyst. The gas produced is reacted with a scavenger in a system to render the gas harmless while achieving the desired function of the gas.

BACKGROUND OF THE INVENTION

This invention relates to a propellant composition and more particularly to a gas-generating propellant composition wherein the gas generated by the propellant can be rendered harmless, and wherein the propellant can be extinguished if the gas pressure exceeds a predetermined pressure.

It is always desirable to produce gas to inflate or pressurize a variety of devices such as balloons and collapsible devices suitable for use by man or gas bags. Gas bags are enclosed units which must be pressurized on occasion. Gas generating propellants are especially suitable to carry out these functions. In utilizing gas generating propellant compositions, some problems arise. One problem is control of the gas generation. Another problem is keeping the temperature of the gas producing composition down. It is further desired that the exhaust gas be non-toxic.

Control of the gas generation centers around controlling the burning of propellant. With certain propellants and apparatus in which the propellants are used, the amount of propellant burned is carefully controlled. In others, storage of propellant components is effected with a mixing just prior to use. Also quick reductions in pressure are used to extinguish propellants when the gas generation has reached a desired point. An increase in pressure customarily enhances gas generation. These controls all require sophistication and complication which increases the possibility of failure and, therefore, the hazard to anyone working around the device using the gas generating composition.

Also in many cases, a chemical reaction for generating gas also produces a high temperature in the 1500°F to 2000°F range. However, this temperature is required to be controlled. A high temperature for gas generating compositions used in a device such as a balloon or liferaft endangers the men near that equipment and increases explosion possibilities.

Even more dangerous than high temperature, is the toxicity of the gas produced by propellants. The gas is required to be non-toxic in order to be suitable for use by men.

Thus it may be seen that gas generating propellant composition is desirable in a man-rated system or for a gas bay if it is subject to simple controls, generated at a low temperature, and non-toxic.

5           Beyond the gas generating propellant itself, further limitations on presently used gas generating systems are also present. Most systems increase the amount of gas generated as the pressure builds up. Excessive controls are required to avoid the problems thus created. The pressure can cause the propellant to crack and  
10       burn more rapidly, producing thereby an excessive amount of gas which in some way must be controlled in order to avoid problems such as explosions.

          Bottled gas generators also create problems. There is a low volume yield of gas. The weight inherent in the system renders  
15       the generator unwieldy. Added to those problems are the tendency of the bottle to leak during storage and the high cost of the bottle gas generator system itself.

#### SUMMARY OF THE INVENTION

          Accordingly an object of this invention is to provide a gas  
20       generating propellant composition which is easily controlled.

21           Another object of this invention is to provide a gas generating propellant composition which generates gas at a low temperature.  
22  
23

Still another object of this invention is to provide a gas generating propellant composition which produces a non-toxic gas.

Yet another object of this invention is to provide a gas generating propellant composition which is suitable for use in devices used extensively by human beings.

A further object of this invention is to provide a system which does not exponentially increase the amount of gas formed with a pressure increase.

A still further object of this invention is to provide a system with a high volume yield of gas.

Yet a further object of this invention is to provide a gas generating system having a mitigated weight problem.

Another object is to provide a gas generating system which will not leak during storage.

Still another object of the invention is to provide a gas generating system having a reduced cost.

These and other objects of this invention are fulfilled by providing a gas-generating, solid, propellant composition which is self-extinguishing at high pressures and which generates a gas that reacts in a system with an easily stored scavenger, the reaction of the gas with the scavenger serving to cool the reaction which produces the gas. The reaction with the scavenger also results in non-toxic materials and gas.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

The major component of the gas-generating systems of this invention is a solid propellant composition which is self-extinguishing at high pressures. The propellant composition comprises a binder, an oxidizer, and a coolant.

A suitable binder is selected from the class of synthetic resins. Suitable binders include polyurethanes. Also, hydroxyl or carboxyl telomerized polyether, polyester, polybutadiene and polyhydrocarbon oligomers of which their non functional analogues can be cast or extruded and subsequently cured to produce dimensionally stable grains are suitable as binders for the propellant. Other binders are suitable also. For example, polyformaldehydes could be used as a binder to reduce methane content of exhaust gases and confer stability at service temperatures without necessitating a post cure. These binders are commercially available and known in the propellant art as indicated by U.S. Patent 3,362,453 to Filter, which is incorporated herein by reference. The binder is usually present in the propellant composition at 5% to 25% by weight of the propellant composition. A more suitable amount of binder is 10% to 24% by weight of the propellant composition. An even more suitable amount of binder is 18% to 22% by weight of the propellant composition.

The oxidizer includes perchlorate and nitrate salts of metals or ammonia. Sodium perchlorate, sodium nitrate, calcium perchlorate, barium nitrate, ammonium nitrate, and ammonium perchlorate are suitable oxidizers. The oxidizer is suitably present in amounts of 45% to 95% by weight of the propellant composition. A more suitable amount of oxidizer is 53% to 82% by weight of the propellant composition. The oxidizer particle size may vary from 1 to 100 microns or 5 to 95 microns, or suitably 10 to 50 microns. Particle size affects the burning rate inversely.

Also in the system for using the gas generating propellant various types of coolants are added. The coolants fall basically into two classes defined as internal coolants or external coolants. The internal coolants are mixed in with and as a part of the propellant composition. The external coolant is present in the system along with scavenger and is not mixed with the propellant.

A suitable internal coolant is an ammonium or metallic salt of an organic or inorganic acid. It is present in the propellant at range of up to 30% by weight of the propellant. A more suitable range of coolant is 5% to 25% by weight of the propellant with 18% to 22% by weight of the propellant being effective also. Suitable salts are chlorides, bromides, iodides, oxalates, citrates, tartrates, and bicarbonates. The metallic portion of the salt is

sodium, potassium, or calcium. Sodium bicarbonate and sodium oxalate are especially suitable as internal coolants because either salt cuts the amount of toxic gas produced by the propellant, and, thereby, assists the scavenger. Ammonium chloride is also a suitable coolant. More than one internal coolant can be used in a propellant composition. In other words it is possible to use a single internal coolant or a mixture of coolants as the internal coolant component of the propellant. The coolant may have a particle size of 1 to 100 microns, or suitably 5-95 microns or more suitably 10 to 50 microns. Particle size affects the burning rate inversely.

While it is not desired to be bound to any particular theory, the following postulate is a possible mechanism which may explain why the solid, gas-generating propellant of this invention is self extinguishing. Under normal propellant burning conditions, the burn depends on heat flux transferred back to the surface of the solid propellant while the propellant is burning. With a coolant present in the propellant, there is no heat transferred back to the propellant. Absent this heat transfer back, the propellant is self extinguishing when pressures build up. This transfer back phenomenon occurs during burning when gases form about one micron from the surface of the propellant. This burning and gas formation create heat flux and pressure which gouge the pro-

increasing exponentially heat, burning, gas, and pressure. The coolant is believed to absorb heat thereby preventing the exponential increase and leading to a pressure-induced extinguishing of the propellant.

5       The temperature at which extinguishing is inversely proportional to the amount of coolant in the propellant. As the amount of coolant goes up, the extinguishing temperature increases. It is usually desired to have the propellant be self-extinguishing at pressures of 700 to 1500 pounds per square inch. About 1000 pounds  
10 per square inch pressure is suitable for extinguishing the propellant. The system in which the propellant is used extinguishes the propellant at the appropriate pressure.

      The propellant is placed in a suitable system so that when the propellant is burned the gas is formed and directed into contact with a scavenger. The scavenger serves to reduce the exhaust  
15 flame temperature to a range of 280°F to 900°F. This temperature range reduces or eliminates the possibility of inadvertant fire or burning of the propellant. The system can be any suitable system such as those used as a collapsible device. In the case of an  
20 inflatable life raft, the propellant is placed inside the life raft. Means are provided for propellant ignition. Upon ignition, gas is  
21 formed by the propellant, The gas fills the interior of the life  
22

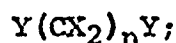
raft thereby inflating the raft. Also in the raft is a scavenger which reacts with the gas to neutralize the gas and form a harmless or non-toxic gas while at the same time holding down the temperature of the gas thus formed to a suitable range.

5           Suitable scavengers for use in the system materials which react with the gas produced by the propellant are those which both produce harmless gas and lower the temperature of the gas produced. Metallic salts of organic and inorganic acids are suitable for purposes of coolant. Especially suitable salts are bicarbonates and carbonates such as those of sodium, potassium, and calcium. 10           The acids and metals combine to form the appropriate salt. Sodium bicarbonate is the most convenient salt to use from a cost standpoint. The scavenger is present in at least a stoichiometric amount in order to neutralize the gas generated by the propellant. Scavengers in excess of the stoichiometric amount can also be present. 15           The system is provided throughout with suitable means for carrying the functions of the solid propellants and other components.

          Additionally 0 to 2% by weight of the composition of a burning rate catalyst is included in the propellant composition. Preferably at least 0.1% of catalyst is present. Although any burning 20           rate catalyst is suitable for use in the propellant composition 21

$\text{Fe}_2\text{O}_3$  appears to be the most convenient to use. The catalyst may have a particle size in the range of the oxidizer or internal coolant. Other suitable catalysts include copper chronite, ferric ferrocyanide, copper sulfate, iron oxide ( $\text{Fe}_2\text{O}_3$ ) and ferrocene derivatives.

Optional external coolants are stored in the collapsible device together with the scavenger and are preferably liquids having a high specific heat, a low freezing point, and high boiling points. Especially suitable liquids for use as an external coolants are liquid fluorocarbons used with singly or in combination. An appropriate liquid fluoro carbon is typified by the structure:



wherein X is selected from the group consisting of fluorine, chlorine, and bromine (F, Cl, or Br) and Y is selected from the group consisting of F, Cl, Br,  $\text{OCF}_3$  or phenyl. The structure must contain F in some form, and this factor limits the substituents. Selection of n requires that the fluorocarbon be liquid. An integer range for n is up to 10 so long as the fluorocarbon remains liquid. The temperature range of the gas-generating propellant composition is cut to 200°F to 250°F by using these external coolants in combination with the scavengers.

The following examples are cited merely to illustrate the invention. No undue limitations are to be drawn therefrom. All parts and percentages are by weight of the propellant unless otherwise specified.

#### EXAMPLE I

A one gallon batch of propellant is prepared which contains 60% by weight ammonium perchlorate based on the propellant, 20% by weight ammonium chloride, 0.1%  $\text{Fe}_2\text{O}_3$ , and 19.9% polyurethane. The polyurethane is the binder; the  $\text{Fe}_2\text{O}_3$  a burning rate catalyst; the ammonium chloride an internal coolant; and the ammonium perchlorate the oxidizer. The propellant is cast and cured into small motors in a standard fashion. Solid strand burning rate data indicates the the burning rate of the propellant at 77°F and 1,000 psi is 0.168 inches per sec, and, the propellant is self-extinguishing at pressures above 1000 psi.

#### EXAMPLE II

The propellant is incorporated into a system. A standard device is employed to ignite the propellant. The system is a deflated liferaft having incorporated internally thereof sufficient sodium bicarbonate to react with the gas produced by the propellant. Upon ignition of the propellant, the gas generated thereby flows into the raft to inflate the raft. When the

raft is inflated to 1000 psi, the propellant ceases to generate gas. The propellant produces HCl gas which reacts with  $\text{NaHCO}_3$  as follows:



The products of this reaction are all non toxic.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that, ~~with the above teachings~~, the invention may be practiced otherwise than as specifically described.

~~What is claimed as new and desired to be secured by Letters~~

~~Patent is as follows:~~